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DIVISION 26 - ELECTRICAL

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 SUBMITTALS
- 1.3 GENERAL REQUIREMENTS

- 2.1 GROUNDING AND BOND WIRES
- 2.2 GROUNDING AND BONDING CONNECTORS
- 2.3 GROUNDING AND BONDING FASTENERS

3.1 GENERAL

3.2 BONDING

- 3.2.1 Types of Bonds
 - 3.2.1.1 Brazing
 - 3.2.1.2 Welding
 - 3.2.1.3 Clamping
 - 3.2.1.4 Structural Joining Methods
- 3.2.2 Cleaning of Bonding Surfaces
- 3.2.3 Bonding Straps and Jumpers
- 3.2.4 Bond Resistance
- 3.2.5 Equipment and Enclosure Bonding
- 3.2.6 Bonding of Conduit and Raceway Systems
 - 3.2.6.1 Rigid Metal Conduit and Terminations
 - 3.2.6.2 Flexible Metal Conduit
- 3.2.7 Protection of Finished Bonds
- 3.3 GROUNDING
 - 3.3.1 Ground Systems
 - 3.3.2 Secure Ground Systems
 - 3.3.3 Equipment Grounding
 - 3.3.4 Grounding Connections
 - 3.3.5 Grounding System Tests
 - 3.3.5.1 Ground Resistance Test

3.3.5.2 Ground Isolation Test
3.3.5.3 Continuity Tests

-- End of Section Table of Contents --

JOHN F. KENNEDY SPACE CENTER (KSC)

KSC-SPEC-Z-0005

(Am 2; 1975) Brazing, Steel, Copper,
Aluminum, Nickel, and Magnesium Alloys

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70

(2005) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 467

(2004) Standard for Grounding and Bonding
Equipment

1.2 SUBMITTALS

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.] [for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Material, equipment, and fixture lists shall be submitted for the following items, including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

Bonding Straps and Jumpers
Connections
Fasteners

SD-02 Shop Drawings

Installation drawings shall be submitted for [Grounding Systems](#) including complete details of equipment layout and design.

SD-03 Product Data

Manufacturer's catalog data shall be submitted for the following items:

[Grounding and Bond Wires](#)
[Grounding and Bonding Connectors](#)
[Grounding and Bonding Fasteners](#)

SD-06 Test Reports

Test Reports shall be submitted for the following tests on grounding systems in accordance with the paragraph entitled, "Grounding System Tests," of this section. The report shall include certified record of ground-resistance tests on each driven ground rod, ground rod assembly, and other grounding electrodes. Record shall include the number of rods driven and their depth at each location to meet the required resistance-to-ground measurements specified. A statement shall be included describing the condition of the soil at the time of measurement.

[Ground Resistance Test](#)
[Ground Isolation Test](#)
[Continuity Tests](#)

1.3 GENERAL REQUIREMENTS

Section [26 00 00.00 40](#) GENERAL ELECTRICAL PROVISIONS applies to work specified in this section.

PART 2 PRODUCTS

2.1 [GROUNDING AND BOND WIRES](#)

Ground wires in conduit shall be insulated.

Ground and bond wires shall be annealed copper, Class B stranded, with 98-percent conductivity. Size of wires shall be in accordance with the requirements of the NEC.

2.2 [GROUNDING AND BONDING CONNECTORS](#)

Grounding and bonding connectors shall conform to the requirements of [UL 467](#).

2.3 GROUNDING AND BONDING FASTENERS

All bolts, nuts, washers, lock washers, etc. used for grounding and bonding connections shall be copper or bronze.

PART 3 EXECUTION

3.1 GENERAL

Bonding and grounding requirements, as a minimum, shall be those specified by NFPA 70 National Electrical Code and the following requirements.

3.2 BONDING

3.2.1 Types of Bonds

Unless otherwise specified herein, bonding of metal surfaces shall be accomplished by brazing, welding, clamping, or structural joining methods, or a combination thereof.

3.2.1.1 Brazing

Brazing solder shall conform to KSC-SPEC-Z-0005.

3.2.1.2 Welding

Welding shall be by exothermic process in which the conductors are joined by molten superheated copper produced by reduction of copper oxide by aluminum. Welding procedure shall include the proper mold and powder charge and shall conform to the manufacturer's recommendations.

3.2.1.3 Clamping

In external locations, clamping shall be used only where a disconnect type of connection is required. Connection device may utilize either spring-loaded jaws or threaded fasteners. Device shall be so constructed that positive contact pressure is maintained at all times. This method includes the use of machine bolts with tooth-type or spring-type lockwashers.

3.2.1.4 Structural Joining Methods

Joints made with high-strength structural bolts, and clean unpainted faying surfaces shall be considered as sufficiently bonded to meet the electrical requirements of this specification. The term "clean" as used herein shall mean that faying surfaces on new steel shall have been blasted to bare metal. Where this condition does not exist, a jumper shall be installed in the form of a 5.2 millimeter diameter (No. 4 AWG) No. 4 AWG bare copper wire exothermally welded at each end to the surfaces involved spanning the connection; or a bond weld, defined as a 6.4 millimeter 1/4-inch or larger fillet weld, with a 50 millimeter 2-inch minimum length across the connection shall be installed. Wire jumpers shall be used across joints employing miscellaneous machine bolts such as those used in stairway construction.

3.2.2 Cleaning of Bonding Surfaces

All surfaces which comprise the bond shall be thoroughly cleaned before joining to remove paint, oxides, and other resistance films from the mating

surfaces. Gentle and uniform pressure along with an appropriate abrasive shall be used to ensure a smooth, uniform surface without "point contacts." Excessive metal shall not be removed from the surface. Clad metals shall be cleaned with a fine steel wool or grit in such a manner that the cladding material is not penetrated by the cleaning process. Bare metal shall then be cleaned with solvent-moistened cheesecloth. Grease, oil, dirt, corrosive preventives, and other contaminants shall also be removed using this same method. This cleaned area shall be allowed to air-dry before connection bond. Bond shall be attached within 1 hour after cleaning. Joint shall be sealed and the exposed surfaces refinished within 2 hours to prevent oxidation. If additional time is required, a corrosion-preventive compound shall be applied until the area can be refinished.

3.2.3 Bonding Straps and Jumpers

Unless otherwise specified, bonding straps and jumpers shall be copper and shall have a cross-sectional area of not less than that of 4.1 millimeter diameter (No. 6 AWG) No. 6 AWG copper wire. Bonding straps and jumpers for shock mounted devices, pivot, hinged, or swivel joints shall be made of flat, tinned-copper, woven-wire braid or flexible stranded wire. Vibration of the strap or jumper by the shock mounted device shall not change its electrical characteristics. Bonding jumper installation shall conform to the following:

- a. Bonds shall be accomplished by brazing or welding in outdoor locations unless a disconnect type of connection is required, in which case clamping with bolts shall be used. For each bolt, a tooth-type lockwasher shall be inserted between the strap and metallic member.
- b. Straps shall be bonded directly to the basic structure rather than through any adjacent parts.
- c. When installed, the straps shall be unaffected electrically by motion or vibration.
- d. Straps shall be installed in an area that is accessible for maintenance.
- e. Single straps shall be used; two or more straps shall not be connected in series.
- f. Straps shall be installed so that they will not restrict movement of structure members.
- g. Straps shall be installed so that they will not weaken structure members to which they are attached.

3.2.4 Bond Resistance

Resistance of any bond connection shall not exceed 0.5 milliohm. Any bonds that exceed this resistance shall be reworked by the Contractor at no additional cost to the Government.

3.2.5 Equipment and Enclosure Bonding

Each metallic enclosure and all electrical equipment shall be bonded to ground. At least one copper connection shall be made from the system

ground point to one or more enclosures in the area such that all enclosures and equipment when properly bonded together provide a low-impedance path to ground.

3.2.6 Bonding of Conduit and Raceway Systems

Metal conduit, fittings, junction boxes, outlet boxes, armored and metal sheathed cable, and other raceways shall be bonded as listed below. Care shall be taken to ensure adequate electrical contact at the joints and terminations.

3.2.6.1 Rigid Metal Conduit and Terminations

All threaded connections must be wrench-tight and the unexposed internal and external threads shall be treated with a corrosion-inhibiting compound.

All exposed threads shall be painted. Conduits entering boxes and enclosures shall be bonded to the box with bonding-type locknuts (one outside and one inside) or locknut and grounding-type bushing. Locknuts that gouge into the metal box when tightened are acceptable.

Conduit systems that are interrupted by PVC dielectric links shall be bonded separately on either side of the link. Under no circumstances shall the dielectric link be jumpered.

3.2.6.2 Flexible Metal Conduit

Short sections of flexible conduit such as those used to terminate conduit on motors, etc., shall be jumpered with a copper jumper unless the flexible conduit has an integral grounding conductor.

3.2.7 Protection of Finished Bonds

Finished bonds shall be protected by painting to match the original finish after bond is made.

3.3 GROUNDING

3.3.1 Ground Systems

Secure [grounding systems](#) shall be installed for power and for instrumentation. Each system shall be independently connected to the building counterpoise as shown on the contract drawings.

3.3.2 Secure Ground Systems

Secure ground systems shall consist of unspliced ground wires in individual welded or epoxied conduit runs from the Secure Area to the building counterpoise. Welding and epoxying shall conform to Section [26 27 26.00 40](#) STANDARD WIRING SYSTEMS.

3.3.3 Equipment Grounding

Electrical continuity of metallic raceway systems shall be ensured with all equipment individually and directly connected to the building ground independent of the raceway system as herein specified.

Enclosures for panelboards shall be individually and directly connected to the building ground. Grounding conductor shall be not less than No. 2 and shall be connected from the building ground to a copper ground-bus terminal

strip located in each panelboard.

All polarized receptacles, lighting fixtures, and equipment enclosures shall be grounded with an identified (green color) insulated conductor, not smaller than 2 millimeter diameter (No. 12) No. 12, connected to the branch circuit ground-bus terminal strip. Ground-bus terminal strip in each panelboard enclosure shall be isolated and independent of the system neutral terminal strip.

Indoor substations, transformers, switchboard frames, motors, generators, frames and tracks of cranes, and other miscellaneous equipment shall be individually and directly connected to the building ground. The current-carrying capacity of the grounding conductor shall be the same as the current-carrying capacity of the power conductors for circuits utilizing power lines size 6.5 millimeter diameter (No. 2) No. 2 and smaller. For circuits with power wiring larger than 6.5 millimeter diameter (No. 2) No. 2, the grounding conductors shall be as specified in the NEC except that the grounding conductors shall not be smaller than 6.5 millimeter diameter (No. 2) No. 2.

Separate equipment grounds shall be provided where indicated.

3.3.4 Grounding Connections

All ground connections shall be bonded connections in accordance with paragraph entitled "Bonding" herein.

All ground connections that are buried or in inaccessible locations shall be welded or silver-soldered. The process shall join all strands and shall in no way cause the parts to be damaged or weakened.

Welding process shall be an exothermic type which will make a connection that will not corrode or loosen. Completed connection or joint shall be equal or larger in size than the conductors joined and shall have the same current-carrying capacity as the largest conductor.

Connections in accessible locations shall be bolted. Connections to steel building columns in accessible locations shall be cast-copper-alloy clamp lugs bolted to the structure.

3.3.5 Grounding System Tests

The following tests shall be performed by the Contractor in the presence of the Contracting Officer.

3.3.5.1 Ground Resistance Test

Grounding systems shall be tested for ground resistance. The total resistance from any point on the ground network to the building counterpoise shall not exceed 50 milliohms.

3.3.5.2 Ground Isolation Test

All ground systems shall be tested for isolation from other ground systems.

3.3.5.3 Continuity Tests

Continuity tests shall be performed on all power receptacles to ensure that the ground terminals are properly grounded to the facility ground system.

-- End of Section --